10/531501
JC13 Rec'd PCT/PTO 13 APR 2005

RADIOFREQUENCY DEVICE OF THE TYPE WITH NIL OR QUASI-NIL INTERMEDIATE FREQUENCY MINIMISING PARASITE FREQUENTIAL MODULATION APPLIED TO AN INTEGRATED LOCAL OSCILLATOR

The present invention relates to the synthesis of frequency and more particularly that utilised in radio frequency devices, receivers or transmitters, of the type with nil or quasi-nil intermediate frequency.

The invention applies advantageously, but not limitatively, to wireless communication systems, and more particularly to cellular mobile telephones.

In a terminal of a wireless communication system, such as for example a cellular mobile telephone, in direct conversion, or transposition with nil intermediate frequency, is an alternative with superheteredyne architecture, and is particularly well adapted to allow architectural solutions which are very strongly integrated for this terminal.

A direct-conversion receiver, or else a receiver with nil intermediate frequency (receiver zero-IF), converts the signal band useful directly around the nil frequency (base band) instead of converting it to an intermediate frequency of the order of a few hundred

MHz.

A direct-conversion transmitter converts the base band of the signal useful directly around the radio frequency carrier frequency.

In this case zero-IF radio frequency devices have difficulty in differentiating the useful signal if continuous parasite signals are present at entry. Also, in certain cases, it is preferred to utilise radio frequency devices with quasi-nil (low IF) intermediate frequency, that is, whereof the intermediate frequency is not strictly nil, rather it is low and in practice lower than one MHz.

Regardless, to generate a useful or quasi-nil intermediate frequency it is necessary to use a local oscillator frequency, or transposition frequency, close to the radio frequency frequency to either cause frequency transposition towards the radio frequency field of the signal to be transmitted (in the case of a transmitter), or to cause frequency transposition downwards, of the signal received (in the case of a receiver).

For the purposes of generating this transposition signal, a synthesiser having a frequency operating at a multiple frequency of the transposition frequency is generally used. And the transposition signal is then generated as it leaves a divider of suitable frequency.

The frequency synthesiser is generally obtained with a voltage-controlled oscillator (VCO) and a phase locked loop (PLL).

Due to imperfections in the chain of emission or receiving, parasite signals (harmonics or mixing

products of useful signals) will exist and will be injected via parasite paths (magnetic coupling, capacitive coupling, etc.) in the voltage-controlled oscillator. The result is frequential parasite modulation applied to the voltage-controlled oscillator. This mechanism is known to the expert in English as VCO PULLING.

More precisely, when a parasite signal at a phase-shifted Δf frequency relative to the output frequency of the local oscillator is applied to a voltage-controlled oscillator and operating at a given output frequency, this oscillator will be modulated in frequency with a frequency equal to Δf and an amplitude proportional to $1/\Delta f$. And, in devices of nil or quasi-nil intermediate frequency, Δf is low, resulting in increased amplitude.

The result of this will be perturbatory modulation at the output of the frequency transposition device or mixer, which is going to lead to less easy decoding of information, and consequently to a more significant error rate.

The effects of these parasite perturbations are modified due to the local oscillator belonging to a phase locked loop.

More precisely, with respect to the phase locked loop, when the oscillator is modulated with a Δf frequency, the output of the charging pump of the phase locked loop in a sinusoidal wave having the Δf frequency. If Δf is greater than the cut-off frequency of the phase locked loop, the voltage control of the oscillator will not be affected. On the contrary, if Δf

is low, that is, less than the cut-off frequency of the phase locked loop, the voltage control of the oscillator will act to reduce the amplitude of the modulation of the oscillator.

Furthermore, since the oscillator is connected to the phase locked loop, this results in a combination of two effects. Accordingly, at low frequency, the phase locked loop will correct perturbation. At high frequency, perturbation will be weak, due to the $1/\Delta f$ effect. On the contrary, in the vicinity of the cut-off frequency of the phase locked loop, there will be an increase in perturbation.

Also, a natural solution would consist of creating a phase locked loop having an elevated cut-off frequency.

However, creating an increased cut-off frequency works against the stability of the loop. In effect, it is generally required, for reasons of stability, that this cut-off frequency is less than a tenth of the reference frequency of the loop.

Now, when the loop creates an entire division in frequency, the reference frequency provides spacing between the channels. Thus, for DCS application in which the channels are spaced every 200 kHz in the 1808 MHz-1880 MHz range, the reference frequency is in practice equal to 400 kHz for an oscillator supplying a frequency of 3.6 GHz.

If the division made in the loop is not a whole division, then a higher reference frequency can be selected. However, using an improper divider is disadvantageous with respect to noise.

All things considered, in a DCS application a loop cut-off frequency of the order of 40 to 50 kHz maximum will be selected, which is largely insufficient to prevent the parasite problems of modulation mentioned hereinabove.

Other solutions can be envisaged to rectify these problems of parasite modulation.

Increased intermediate transposition frequencies, of the order of several MHz, can be used. However, this leads to an increase in current consumption of the receiver or transmitter.

An oscillator supplying an output frequency which is an increased multiple of the required transposition frequency can also be used. But, this will have an impact on current consumption and will necessitate use of particularly complex technology.

Finally, the attempt can be made to improve the insulation of the oscillator. But, this is particularly delicate to do on a chip, in particular when the chip also incorporates the frequency transposition means (or mixer).

The aim of the invention is to provide a more satisfactory solution to the problems of frequential parasite modulation applied to the oscillator, and quite particularly when this oscillator and the mixer are integrated on the same chip.

The invention thus proposes a radio frequency device of the type with nil or quasi-nil intermediate frequency, intended to receive or transmit a radio frequency signal whereof the send or receive frequency belongs to a frequency range subdivided into

frequential channels.

According to a general characteristic of the invention the radio frequency device, consequently capable of being a radio frequency receiver or a radio frequency transmitter, comprises on the same electronic chip means of frequency transposition connected to a so-called main local oscillator.

Furthermore, the main oscillator is incorporated within a main phase locked loop whereof the reference frequency is supplied by a voltage-controlled auxiliary oscillator, itself incorporated in an auxiliary phase locked loop whereof the reference frequency is less than the frequency of the auxiliary oscillator.

Furthermore, the reference frequency of the main loop, that is, the frequency of the auxiliary oscillator, is less than the output frequency of the main oscillator. It is furthermore greater than ten times the frequential spacing of the channels reduced to the output frequency of the main oscillator. In addition, this reference frequency of the main loop is removed by a whole multiple of the send or receive frequency of at least the cut-off frequency of the main loop.

In other words, the invention proposes a frequency synthesiser with double phase locked loop.

A first oscillator, an auxiliary oscillator, allows all the desired characteristics for the transposition signal (channel selection, stability, phase noise, etc.) to be attained. This oscillator is controlled by the auxiliary loop. As this auxiliary oscillator oscillates at a frequency which does not

correspond to any harmonic nor produces a mix of useful signals, it will not be perturbed.

A second oscillator, a main oscillator, oscillating for example at twice the transposition frequency, will be controlled by the main loop in taking the output frequency of the oscillator auxiliary as reference. As the reference frequency of the main loop is relatively high, the loop filter can have a relatively wide pass-band, of the order of several tens of MHz, having the following advantages:

- all the interference will be reduced by the loop gain,
- the phase noise of the main oscillator will be directly given by the noise of the auxiliary oscillator.

As a consequent, it is not necessary to provide a high-performance oscillator, as a simple ring oscillator will be adequate.

When the auxiliary loop is intended for use with a whole divider, the reference frequency of the auxiliary loop is less than or equal to, preferably equal to, the frequential spacing of the channels reduced to the reference frequency of the main loop.

Furthermore, according to an embodiment of the invention, the reference frequency of the main loop is greater than the a twentieth of the output frequency of the main oscillator.

Therefore, in an embodiment in which the range of frequencies to which the send or receive frequency belongs is in the vicinity of 900 MHz or 1800 MHz (corresponding to the GSM or DCS standard), the

reference frequency of the main loop can be taken as equal to 450 MHz, whereas the reference frequency of the auxiliary loop can be equal to 50 kHz. The output frequency of the main oscillator can then be equal to 3.6 GHz.

The electronic chip, which already comprises the frequency transposition means as well as the local main oscillator, may also comprise the two phase locked loops.

Moreover, the device can be integrally produced on the electronic chip.

The invention also proposes a component of a wireless communications system, for example a cellular mobile telephone, incorporating a radio frequency device, such as defined hereinabove.

Other advantages and characteristics of the invention will emerge from examining the detailed description of a non-limiting embodiment, and the attached diagrams, in which:

- Figure 1diagrammatically illustrates a cellular mobile telephone incorporating in its transmission chain a frequency synthesiser according to the present invention;

- Figure 2diagrammatically illustrates a cellular mobile telephone incorporating in its transmission chain a frequency synthesiser according to the present invention; and

- Figure 3illustrates in greater detail, though still diagrammatically, an embodiment of a synthesiser according to the present invention.

In Figure 1 the reference TP designates a cellular

mobile telephone intended in this example to function according to the DCS standard. In the DCS standard, the transmission frequency of the radio frequency signal or the reception frequency is part of a frequency range of between 1808 MHz and 1880 MHz, this frequency range being subdivided into frequency channels spaced at 200 kHz.

A voltage-controlled oscillator, to be designated hereinafter as 'main oscillator', bears the reference VCOP and emits an output signal SSP at an output frequency here equal to 3.6 GHz. This main VCOP oscillator is followed by a frequency divider by two oscillators, designated as DV, supplying a transposition signal ST at a frequency of 1.8 GHz.

A complex mixer MX (that is, processing the two channels I and Q in phase quadrature) receives, on the one hand, the transposition signal ST and, on the other hand, a useful signal in base band SUBB delivered by the processor in base band PBB of the telephone TP. At the mixer output the signal is modulated around the frequency of 1.8 MHz and is then transmitted by the antenna ANT of the telephone after passing into a preamplification stage PPA followed by a power amplification stage PA.

In the reception chain of the telephone TP, such as illustrated in Figure 2, and connected to the output chain by a duplexer not shown here, the signal received by the antenna ANT is amplified in a low-noise amplifier LNA. Next, the signal is transposed in base band to the mixer MX by using the frequency transposition signal ST, likewise originating from a

VCOP oscillator.

The useful signal in base band SUBB is then supplied after amplification and numerical analogue conversion to the processor in base band PBB of the telephone TP.

The expert will therefore note that the architecture described here for the chain of output or reception of the telephone TP is a so-called 'zero IF' architecture, that is, with a nil intermediate frequency.

This being the case, the invention also applies to radio frequency receivers or radio frequency transmitters of the type having a quasi-nil intermediate frequency, that is, for example less than 1 MHz.

In high-integration solutions, currently recommended, the frequency transposition stage (or mixer) and the main oscillator VCOP are situated on the same electronic chip PC.

Due to imperfections in the send or receive chain, parasite signals (frequency harmonics or mixing products of useful signals) will appear and will be injected via parasite paths into the main oscillator, resulting in frequential parasite modulation applied to this main oscillator, and known to those skilled in the art by the English name of 'VCO PULLING'.

The aim of the invention is to provide a solution to this problem, particularly critical when the main oscillator VCOP and the mixer MX are on the same chip PC.

In addition, the invention proposes a frequency

synthesiser having phase locked loops PLL1 and PLL2, such as shown in Figure 3.

More precisely, the main oscillator VCOP is incorporated into a 'main' phase locked loop, and designated as PLL2. This phase locked loop conventionally comprises a front detector PFD2 followed by a charging pump CP2 and a loop filter FB2. The output of the loop filter controls the voltage oscillator VCOP. The oscillator output VCOP supplies the signal SSP, and the output signal is also divided by a whole number k2 into a whole divisor DV2 before being compared to a reference signal SRFP in the front detector PFD2.

The reference signal SRFP is delivered by a voltage-controlled oscillator VCOA, itself incorporated into an auxiliary phase locked loop designated as PLL1. The architecture of this loop PLL1 is similar to that of the loop PLL2, with the difference that the whole division is this time carried out divisor DV1 by using a whole number k1.

Furthermore, the reference signal SRFA of the loop PLL1 is supplied by an external generator, for example quartz.

In general, the frequency of the signal SRFP must be large to have a sufficiently wide band-pass of the loop PLL2, typically greater than 1 MHz, and in such a way that the loop PLL2 sharply reduces the effect of PULLING to which the oscillator VCOP is subject.

Furthermore, the frequency of the signal SRFP must be in a non-contaminated zone, that is, removed by a whole multiple of the send or receive frequency, by at

least the cut-off frequency of the main loop.

Accordingly, by way of example, for a telephone operating according to the DCS standard a frequency of 450 MHz for the signal SRFP can be selected. The cut-off frequency of the loop can then be selected up to 1/10 of the frequency of the signal SRFP, here 45 MHz. In this case the choice will be guided by criteria peculiar to the application (noise, consumption, etc.).

Furthermore, since the frequential spacing of the channels is 200 kHz for an output receiving frequency in the vicinity of 1.8 GHz (corresponding to frequential spacing of 400 kHz for a frequency of the signal SSP equal to 3.6 GHz, or else to spacing of 50 kHz for the frequency of 450 MHz of the signal SRFP), a frequency of 50 kHz for the reference signal SRFA will be selected.

Thus the reference frequency of the auxiliary loop is equal to the frequential spacing of the channels, reduced to the reference frequency of the main loop.

Since the oscillator VCOA oscillates at a frequency in a non-contaminated zone, that is, not corresponding to any harmonic nor produced from a mix of useful signals, it will not be perturbed.

Furthermore, the main oscillator VCOP is subject to PULLING. However, the effect will be strongly reduced by the loop gain of the loop PLL2.